Experience Gained of the Reported Nuclear or Radiological Accident at Nuclear and Radiological Installations

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Abstract

The application of radioisotopes in medicine, industry, agriculture and research is the major activities that belong to the nuclear and radiological industries in Egypt. From a radiation safety and security of the sources standpoint, accident investigation is necessary to determine what happened, why, when and how it occurred and who were involved and be responsible. This paper aims to statistical evaluation of the reported accidents at "USIE" which is an "IAEA" web portal for contact point of state's members, in the period from Jun 2008 to March 2012. The study describes the major Nuclear or radiological (N/R) accidents that had happened during the above period, and provides a methodology for analysis, lessons learned and the associated hazards on the environment, workers and public health. This study will help the regulatory authority to review the reasons of vulnerabilities, and to start a radiation safety and security program to introduce measures capable to avoid the recurrence of similar events.

Keywords

Risk Assessment; Accident's Root Causes; Emergency; INES Rate; Categorization

Introduction

The aim of the conduction of an examination on previous radiological or nuclear emergencies is to identify lessons that should be considered in the future. The national nuclear/radiological emergency plan must be continuously developed and improved on the basis of comprehensive risk assessment and the lessons learned from the previous accidents. A rigorous examination on the response to emergencies of the reported events has shown that there is a need for additional consistent international guidance on taking protective and other response actions as well as for making the guidance in a context to be comprehensive for the decision makers and readable for the public (IAEA 2003). To enhance the national capabilities of the member states in the field of (N/R) emergency preparedness and response, IAEA has established series of safety standards which provide a consistent, reliable means to ensure the effective fulfillment of obligations under the conventions. These standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education (IAEA 2003). The Incident and Emergency Center in IAEA has established a communication system to enhance the capabilities of the State's Parties to facilitate the request assistance in case of nuclear and radiological accidents through the net of assistance between IAEA and state's parties to Response and Assistance Network (RANET).

Unified System for Information Exchange in Incidents and Emergencies (USIE), an (RANET/ IAEA web) portal for Contact Points of State's Parties in RANET aims at exchanging urgent information during nuclear and radiological incidents and emergencies, through the officially nominated National Contact Point Officers to post information on the rating of events using the International Nuclear Event Scale (INES) applied to any event associated with the transport, storage and use of radioactive material and radiation sources. Such events can include industrial and medical uses of radiation sources, operations at nuclear facilities, or the transport of radioactive material. Events are classified into seven levels: Levels 1–3 are "incidents" and Levels 4–7 "accidents". These levels consider three areas of impact: people and the environment, radiological barriers and control, and defense in depth. The scale is designed so that the severity of an event is about ten times greater for each increase in level on the scale. Events without safety significance are called "deviations" and are classified as Below Scale/Level (Nuclear safety & security 2012). Based

on a radiation safety and security, accident investigation conclusion is an important process toward alertness and feedback to avoid Disorderly conduct by improving the comprehension of safety performance and safety culture. Accident investigation is the first step toward the avoiding of future injures and financial losses by prevention of recurrence. On the other hand, accident investigation is also essential for the establishment of the responsibilities and liability for the consequences (Rozental 2002). Evaluation and analysis of the previous reported accidents at USIE/RANET from June 2008 to March 2012 were concluded in this study for lessons to improve the capabilities of emergency plan in response to different accidents in Egypt.

Material and Methods

As from June 2008 to 31March 2012, the INES contained a total of 60 confirmed incidents reported by participating States represented in figure (1). While Figure (2) represents the type of incident with their RANET Scale. The 60 confirmed incidents are categorized as follows: i) 22 incidents including radiation sources mainly industrial radiography cause an overexposure to workers and the public, the most severe radiological accidents are those under INES rates 2 and 3. These accidents occurred in South Korea, Perue and USA respectively, where the workers were overexposed to radiographer camera. ii) 5 incidents are grouped as radiological facilities including overexposure due to gamma irradiators or accelerators, and the most severe reported accident at rate 4 is in Bulgaria's Gamma-irradiator facility (GIF) loaded with 12 Co-60 sources with a total activity of 421 TBq. The accident is caused due to human error during rearrangement assemblies and imitators in the GIF. iii) 10 NPP operation incidents were reported.

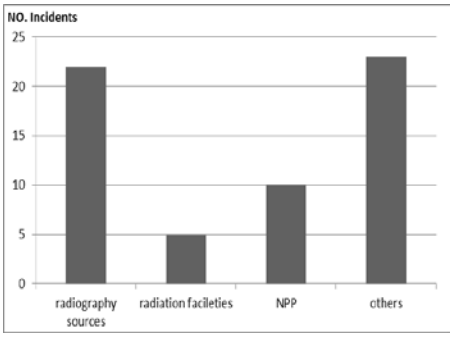

FIG.1 GRAPHICAL REPRESENTATION FOR INCIDENTS DURING THE PERIOD FROM JUNE 2008 TO MARCH 2012

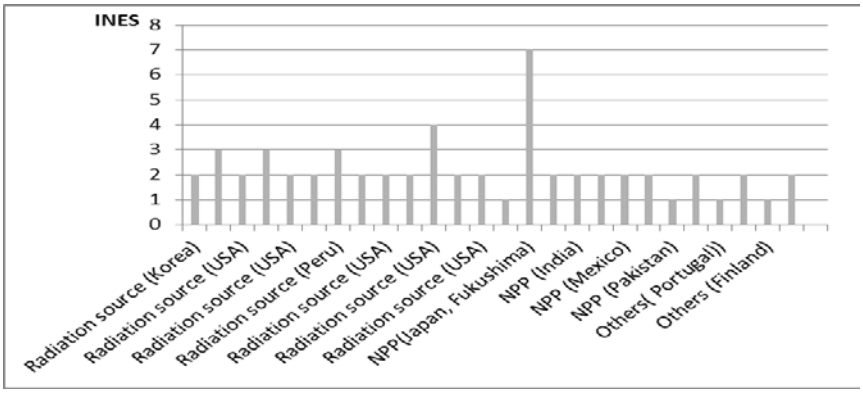

FIG. 2 RANET SCALE OF THE DIFFERENT TYPES OF THE REPORTED ACCIDENTS

Figure (2) represents the rated accidents reported by IAEA. As in figure (2) few numbers of NPP incidents are represented as rate-2 at INES scale and no impact onsite facility or environment except Fukushima Diiach in Japan due to tsunami. Fukushima Daiichi nuclear power plant crisis along with the events at units 1, 2 and 3 has been rated at Level 7 (major release of radioactive material with widespread health and environmental effects), on the INES, and those at unit 4 as Level 3 (Serious Incident) events (Evelyn et al. 2011). Its consequence was evacuation 20 km far away Fukushima. The evacuation zone encompassed 50,000 people living within 20 km of the facility. The accident is the second biggest nuclear accident after the Chernobyl disaster, but more complex as all reactors are involved (International Business Times, Australia 2011). iv) 23 incidents reported include loss of radioactive sources and founding contaminated goods which is free from harm to the public or the environment.

Incidents in Egypt during the studied period were as follow: The first classified by regulatory body as radiation facilities, where a high level of radioactivity occurred in Deionizer unit of Gamma Irradiator in National Center for Radiological Research and Technology (NCRRT). The radioactivity levels due to leakage in Pencil integrity. The incident led to contamination of 20 m3 water, but without impact on human or environment. The RANET was informed

by the Egyptian regulatory body and the incident has no rating on the INES scale by IAEA where it doesn't have any impact on the environment and the workers, and it is excluded from the level of INES. Other incidents are classified as others by the regulatory body. There is detection of high radiation level from Cars carrying a load out from the border of Damietta Port two times. More investigations have showed that the contamination was due to cobalt-60, while the first was in a small steel area from the trailer (0.5 mSv/h on the surface of the contaminated area), and the second was in the steel center of the wheel of the car with dose (3 μSv/h). The last incident is a detection of high radiation level (1.7mSv/h) at hot spot in storing room of nuclear medicine department in university hospital. By a comprehensive survey and monitoring, the inspectors found that a metallic needle of ^{226}Ra out of their capsule stacked between the shielding storage box and next wall. The source was recovered and the radiation level was returned to the background level.

IAEA provides a plain language statement of the risk to the public for an uncontrolled dangerous source *(IAEA 2003*). The risks are assessed on the assumption that the source or material concerned is not managed safely or kept securely. The statements are given for different ranges of the A/D value described by the following equation:

$$\text{Dangerous Index} = A/D$$

(Where, A is Activity of the source TBq and D is Dangerous factor). The value A/D, a radioactive source, is considered to be a 'dangerous' source as it has a significant potential to cause severe deterministic effect if not managed safely and contained securely(Second European IRPA congress on radiation protection Paris, May 15-19, 2006). Table (1) illustrates danger derived from each categorization according to A/D value.

TABLE 1 DANGER DERIVED FROM EACH CATEGORY SOURCE:

Category	A/D	Risk due to direct exposure
1	A/D> 1000	Extremely dangerous
2	1000>A/D> 10	Very dangerous
3	10>A/D> 1	Dangerous
4	1>A/D> 0.01	Les dangerous
5	0.01>A/D> Exemption level (EL)	No dangerous

Results and Discussion

Upon the selected period, it is shown that the probability of the occurring of radiological accident is the most frequent rather than the nuclear as in figure (3). It is clear that the number of nuclear accidents represents 2% from the total reported incidents in which radiological accidents represent 98%. Fukushima nuclear accident is the most dangerous NPP reported accident in the studied period.

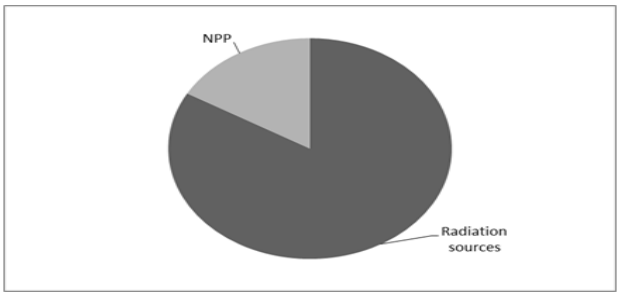

FIG. 3 CATEGORIZED OF INCIDENTS ACCORDING TO TYPE OF EVENTS

Radiation levels near the plant peaked at 400 mSv/h after the earthquake and tsunami, due to damage sustained, which resulted in increasing recorded radiation levels across Japan (Japan quake 2011). Radiological Contamination 17 people (9 TEPCO employees, 8 subcontractor employees) suffered from deposition of radioactive material to their faces, but they were not taken to the hospital because of low levels of exposure. One worker suffered from significant exposure during "vent work," and was transported to an offsite center; 2 policemen exposed to radiation were decontaminated; and Firemen exposed to radiation are under investigation (IAEA, 2011). The Fukushima accident resulted in unprecedented alertness to review the safety of nuclear installations in Europe and worldwide. Initiatives were taken at national, regional and international level (EUROPEAN COMMISSION 2012). There has been a significant re-evaluation of existing nuclear power programs in many countries. American Society of Mechanical Engineers (ASME) has examined the safety consequences towards a "new nuclear safety constructwhich seeks to better serve society and provides a platform for enhancing nuclear power plants worldwide, review of the disaster in Japan- including an assessment of causes, consequences and socio-political and economic impact (ASME 2012).

Table (2) represents the major radiological reported accidents with their dangerous indexes and their health consequence. It is clear that the most dangerous accident is Bulgaria with category 1. Based on reported accidents analysis, industrial radiographic accidents more frequently cause severe

overexposure for workers. Suffering fom severe overexposure from an industrial radiography in Peru, victims were traveled to France for treatment acco the failure to follow procedures, insufficient training and regulatory control, inadequate maintenance, equipment malfunction and no cases willful violation.

TABLE 2 THE DANGEROUS INDEXES OF THE REPORTED ACCIDENTS AND THEIR HEALTH CONSEQUENCES:

Place	Source	A/D	Category	Health consequence
Bulgaria	Co-60	1400	1	one worker received a total dose of 5,63 Gy and four other workers received total doses in the range of 1,23 Gy to 3,44 Gy. As a result of the overexposure, deterministic effects occurred (acute radiation syndrome).
South Korea	Ir-192	26.2	2	Overexposure to two workers
Peru	Ir-192	40.0	2	sever exposure to one worker
USA	Ir-192	16.8	2	Over exposure to one worker
USA	Ir-192	17.1	2	Over exposure to one worker
USA	Ir-192	7.6	3	Over exposure to one worker
Czech Republic	Co-60	0.33	5	Overexposure to member of public and Foundry man exposed to 50-80 mSv Whole body and 0.1-10Sv hands
Finland	Am-241	0.007	5	No environment impact

Conclusion

This paper makes a quantitative evaluation on the occurrence of accidents and incidents at nuclear and radiological installations using previously reported information at "IAEA" web portal for contact point of state's members "USIE", in the period from June 2008 to March 2012 using INES scale. The danger index A/D according to categorization is calculated for assessment on the risk and health consequences. On the other hand, lessons and recommendations have been concluded to avoid hazard consequences.

Lessons learned can be summarized as follow: Experiences were gained for strengthening the internal capability to emergency response and disseminating the concept of information to avoid hazard consequences of nuclear or radiological accidents. At the national levels and for any accidents, the regulatory authorities should perform an investigation to determine the causes, contributing factor, lessons learned, recommendations in order to prevent the occurrence of such events. The investigation shall be conducted as soon as possible after the eventas well as to construct legal and regulatory framework, to develop the regulations and basic resources necessary to establish an effective regulatory programme to achieve safety and security goals in a manner compatible with national resources and needs. Information exchange strengthens capabilities of member states to analyze causes taking into consideration more safety arrangement to avoid frequent same accidents and widespread radioactive contamination of the environment and learn more lessons to response in Radiological/Nuclear emergencies. From this study, it is noticed that from the reported accidents, the nuclear accidents of NPP, represents 2% while other incidents represents 98%. This may due to small number of nuclear power plant in comparison to other radiological activities and the human contributions in operation is minor and inherently safety systems are operated automatically.

Safety Culture and Information Dissemination must be taken into consideration in establishing the national nuclear and radiological regulatory infrastructure.

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